IB DIPLOMA PROGRAMME
PROGRAMME DU DIPLÔME DU BI
PROGRAMA DEL DIPLOMA DEL BI

CHEMISTRY
HIGHER LEVEL
PAPER 1

Tuesday 18 May 2004 (afternoon)

1 hour

INSTRUCTIONS TO CANDIDATES

- Do not open this examination paper until instructed to do so.
- Answer all the questions.
- For each question, choose the answer you consider to be the best and indicate your choice on the answer sheet provided.

The Periodic Table

Atomic Number
Element
Atomic Mass

1	2											3	4	5	6	7	0
1 **H** 1.01																	2 **He** 4.00
3 **Li** 6.94	4 **Be** 9.01											5 **B** 10.81	6 **C** 12.01	7 **N** 14.01	8 **O** 16.00	9 **F** 19.00	10 **Ne** 20.18
11 **Na** 22.99	12 **Mg** 24.31											13 **Al** 26.98	14 **Si** 28.09	15 **P** 30.97	16 **S** 32.06	17 **Cl** 35.45	18 **Ar** 39.95
19 **K** 39.10	20 **Ca** 40.08	21 **Sc** 44.96	22 **Ti** 47.90	23 **V** 50.94	24 **Cr** 52.00	25 **Mn** 54.94	26 **Fe** 55.85	27 **Co** 58.93	28 **Ni** 58.71	29 **Cu** 63.55	30 **Zn** 65.37	31 **Ga** 69.72	32 **Ge** 72.59	33 **As** 74.92	34 **Se** 78.96	35 **Br** 79.90	36 **Kr** 83.80
37 **Rb** 85.47	38 **Sr** 87.62	39 **Y** 88.91	40 **Zr** 91.22	41 **Nb** 92.91	42 **Mo** 95.94	43 **Tc** 98.91	44 **Ru** 101.07	45 **Rh** 102.91	46 **Pd** 106.42	47 **Ag** 107.87	48 **Cd** 112.40	49 **In** 114.82	50 **Sn** 118.69	51 **Sb** 121.75	52 **Te** 127.60	53 **I** 126.90	54 **Xe** 131.30
55 **Cs** 132.91	56 **Ba** 137.34	57 † **La** 138.91	72 **Hf** 178.49	73 **Ta** 180.95	74 **W** 183.85	75 **Re** 186.21	76 **Os** 190.21	77 **Ir** 192.22	78 **Pt** 195.09	79 **Au** 196.97	80 **Hg** 200.59	81 **Tl** 204.37	82 **Pb** 207.19	83 **Bi** 208.98	84 **Po** (210)	85 **At** (210)	86 **Rn** (222)
87 **Fr** (223)	88 **Ra** (226)	89 ‡ **Ac** (227)															

†	58 **Ce** 140.12	59 **Pr** 140.91	60 **Nd** 144.24	61 **Pm** 146.92	62 **Sm** 150.35	63 **Eu** 151.96	64 **Gd** 157.25	65 **Tb** 158.92	66 **Dy** 162.50	67 **Ho** 164.93	68 **Er** 167.26	69 **Tm** 168.93	70 **Yb** 173.04	71 **Lu** 174.97
‡	90 **Th** 232.04	91 **Pa** 231.04	92 **U** 238.03	93 **Np** (237)	94 **Pu** (242)	95 **Am** (243)	96 **Cm** (247)	97 **Bk** (247)	98 **Cf** (251)	99 **Es** (254)	100 **Fm** (257)	101 **Md** (258)	102 **No** (259)	103 **Lr** (260)

1. How many hydrogen atoms are contained in one mole of ethanol, C_2H_5OH?

A. 5

B. 6

C. 1.0×10^{23}

D. 3.6×10^{24}

2. The percentage by mass of the elements in a compound is

$$C = 72\%, \quad H = 12\%, \quad O = 16\%.$$

What is the mole ratio of C : H in the empirical formula of this compound?

A. 1 : 1

B. 1 : 2

C. 1 : 6

D. 6 : 1

3. What is the coefficient for $O_2(g)$ when the equation below is balanced?

$$\_\_C_3H_8(g) + \_\_O_2(g) \rightarrow \_\_CO_2(g) + \_\_H_2O(g)$$

A. 2

B. 3

C. 5

D. 7

4. How many protons, neutrons and electrons are there in the species $^{26}Mg^{2+}$?

	Protons	Neutrons	Electrons
A.	10	14	12
B.	12	14	10
C.	12	26	10
D.	14	12	12

5. What is the total number of p orbitals containing one or more electrons in germanium (atomic number 32)?

A. 2

B. 3

C. 5

D. 8

6. Which of the physical properties below decrease with increasing atomic number for both the alkali metals and the halogens?

I. Atomic radius

II. Ionization energy

III. Melting point

A. I only

B. II only

C. III only

D. I and III only

7. Which of the following oxides is (are) gas(es) at room temperature?

I. SiO_2

II. P_4O_6

III. SO_2

A. I only

B. III only

C. I and II only

D. II and III only

8. Which of the reactions below occur as written?

I. $Br_2 + 2I^- \rightarrow 2Br^- + I_2$

II. $Br_2 + 2Cl^- \rightarrow 2Br^- + Cl_2$

A. I only

B. II only

C. Both I and II

D. Neither I nor II

9. Based on electronegativity values, which bond is the most polar?

A. B—C

B. C—O

C. N—O

D. O—F

10. Which of the following species is (are) planar (has (have) all the atoms in one plane)?

I. CO_3^{2-}

II. NO_3^-

III. SO_3^{2-}

A. I only

B. II only

C. I and II only

D. II and III only

11. Which substance is most soluble in water (in mol dm^{-3}) at 298 K ?

A. CH_3CH_3

B. CH_3OCH_3

C. CH_3CH_2OH

D. $CH_3CH_2CH_2CH_2OH$

12. What is the molecular shape and the hybridization of the nitrogen atom in NH_3 ?

	Molecular shape	**Hybridization**
A.	tetrahedral	sp^3
B.	trigonal planar	sp^2
C.	trigonal pyramidal	sp^2
D.	trigonal pyramidal	sp^3

13. Which statement about sigma and pi bonds is correct?

A. Sigma bonds are formed only by s orbitals and pi bonds are formed only by p orbitals.

B. Sigma bonds are formed only by p orbitals and pi bonds are formed only by s orbitals.

C. Sigma bonds are formed by either s or p orbitals, pi bonds are formed only by p orbitals.

D. Sigma and pi bonds are formed by either s or p orbitals.

14. For which set of conditions does a fixed mass of an ideal gas have the greatest volume?

	Temperature	**Pressure**
A.	low	low
B.	low	high
C.	high	high
D.	high	low

15. When the solids $Ba(OH)_2$ and NH_4SCN are mixed, a solution is produced and the temperature drops.

$$Ba(OH)_2(s) + 2NH_4SCN(s) \rightarrow Ba(SCN)_2(aq) + 2NH_3(g) + 2H_2O(l)$$

Which statement about the energetics of this reaction is correct?

A. The reaction is endothermic and ΔH is negative.

B. The reaction is endothermic and ΔH is positive.

C. The reaction is exothermic and ΔH is negative.

D. The reaction is exothermic and ΔH is positive.

16. Using the equations below

$$\mathrm{Cu(s) + \tfrac{1}{2}O_2(g) \rightarrow CuO(s)} \qquad \Delta H^{\ominus} = -156\ \mathrm{kJ}$$
$$\mathrm{2Cu(s) + \tfrac{1}{2}O_2(g) \rightarrow Cu_2O(s)} \qquad \Delta H^{\ominus} = -170\ \mathrm{kJ}$$

what is the value of $\Delta H^{\ominus}$ (in kJ) for the following reaction?

$$\mathrm{2CuO(s) \rightarrow Cu_2O(s) + \tfrac{1}{2}O_2(g)}$$

A. 142

B. 15

C. –15

D. –142

17. Which reaction has the most negative $\Delta H^{\ominus}$ value?

A. $\mathrm{LiF(s) \rightarrow Li^{+}(g) + F^{-}(g)}$

B. $\mathrm{Li^{+}(g) + F^{-}(g) \rightarrow LiF(s)}$

C. $\mathrm{NaCl(s) \rightarrow Na^{+}(g) + Cl^{-}(g)}$

D. $\mathrm{Na^{+}(g) + Cl^{-}(g) \rightarrow NaCl(s)}$

18. Which reaction occurs with the largest increase in entropy?

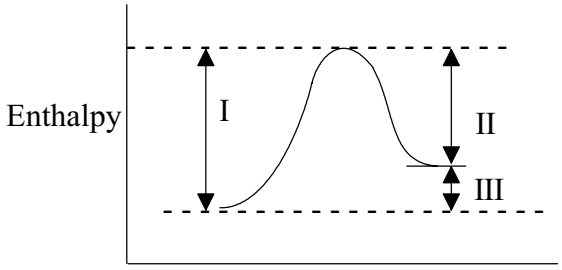
A. $\mathrm{Pb(NO_3)_2(s) + 2KI(s) \rightarrow PbI_2(s) + 2KNO_3(s)}$

B. $\mathrm{CaCO_3(s) \rightarrow CaO(s) + CO_2(g)}$

C. $\mathrm{3H_2(g) + N_2(g) \rightarrow 2NH_3(g)}$

D. $\mathrm{H_2(g) + I_2(g) \rightarrow 2HI(g)}$

19. Which of the quantities in the enthalpy level diagram below is (are) affected by the use of a catalyst?



A. I only

B. III only

C. I and II only

D. II and III only

20. What is the definition of *half-life* for a first order reaction?

A. The time required for the quantity of a reactant to decrease by half.

B. Half the time required for a reactant to be completely used up.

C. Half the time required for a reaction to reach its maximum rate.

D. The time required for a reaction to reach half of its maximum rate.

21. Values of a rate constant, k, and absolute temperature, T, can be used to determine the activation energy of a reaction by a graphical method. Which graph produces a straight line?

A. k versus T

B. k versus $\frac{1}{T}$

C. $\ln k$ versus T

D. $\ln k$ versus $\frac{1}{T}$

22. In the reaction below

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad \Delta H = -92 \text{ kJ}$$

which of the following changes will increase the amount of ammonia at equilibrium?

I. Increasing the pressure

II. Increasing the temperature

III. Adding a catalyst

A. I only

B. II only

C. I and II only

D. II and III only

23. For the reaction below

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$$

at a certain temperature, the equilibrium concentrations are (in mol dm^{-3}):

$$[H_2] = 0.30, [I_2] = 0.30, [HI] = 3.0$$

What is the value of K?

A. 5.0

B. 10

C. 15

D. 100

24. A buffer solution can be prepared by adding which of the following to $50\,cm^3$ of $0.10\,mol\,dm^{-3}$ $CH_3COOH(aq)$?

I. $50\,cm^3$ of $0.10\,mol\,dm^{-3}$ $CH_3COONa(aq)$

II. $25\,cm^3$ of $0.10\,mol\,dm^{-3}$ $NaOH(aq)$

III. $50\,cm^3$ of $0.10\,mol\,dm^{-3}$ $NaOH(aq)$

A. I only

B. I and II only

C. II and III only

D. I, II and III

25. Which equation represents an acid-base reaction according to the Lewis theory **but not** according to the Brønsted-Lowry theory?

A. $CO_3^{2-}(aq) + 2H^+(aq) \rightarrow H_2O(l) + CO_2(g)$

B. $Cu^{2+}(aq) + 4NH_3(aq) \rightarrow Cu(NH_3)_4^{2+}(aq)$

C. $BaO(s) + H_2O(l) \rightarrow Ba^{2+}(aq) + 2OH^-(aq)$

D. $NH_3(g) + HCl(g) \rightarrow NH_4Cl(s)$

26. What is the concentration of OH^- ions (in $mol\,dm^{-3}$) in an aqueous solution in which $[H^+] = 2.0 \times 10^{-3}\,mol\,dm^{-3}$? ($K_w = 1.0 \times 10^{-14}\,mol^2\,dm^{-6}$)

A. 2.0×10^{-3}

B. 4.0×10^{-6}

C. 5.0×10^{-12}

D. 2.0×10^{-17}

27. What is the relationship between K_a and pK_a?

A. $pK_a = -\log K_a$

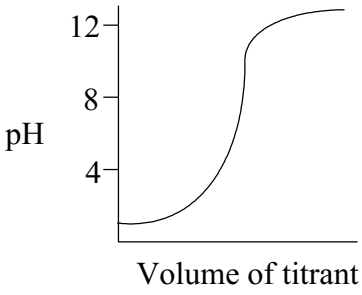
B. $pK_a = \frac{1.0 \times 10^{-14}}{K_a}$

C. $pK_a = \log K_a$

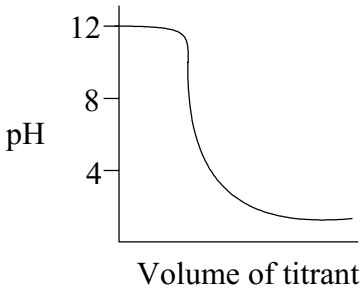
D. $pK_a = \frac{1.0}{K_a}$

28. Which curve is produced by the titration of a $0.1\ \text{mol dm}^{-3}$ weak base with $0.1\ \text{mol dm}^{-3}$ strong acid?

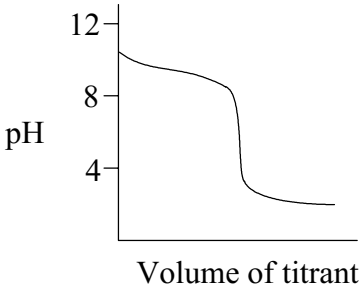
A.



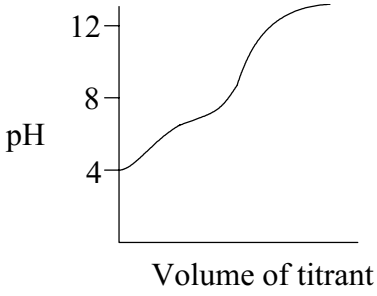
B.



C.



D.



29. What happens to the $Cr^{3+}(aq)$ ion when it is converted to $CrO_4^{2-}(aq)$?

A. Its oxidation number decreases and it undergoes reduction.

B. Its oxidation number decreases and it undergoes oxidation.

C. Its oxidation number increases and it undergoes reduction.

D. Its oxidation number increases and it undergoes oxidation.

30. The following reactions are spontaneous as written.

$$Fe(s) + Cd^{2+}(aq) \rightarrow Fe^{2+}(aq) + Cd(s)$$
$$Cd(s) + Sn^{2+}(aq) \rightarrow Cd^{2+}(aq) + Sn(s)$$
$$Sn(s) + Pb^{2+}(aq) \rightarrow Sn^{2+}(aq) + Pb(s)$$

Which of the following pairs will react spontaneously?

I. $Sn(s) + Fe^{2+}(aq)$

II. $Cd(s) + Pb^{2+}(aq)$

III. $Fe(s) + Pb^{2+}(aq)$

A. I only

B. II only

C. III only

D. II and III only

31. What is the coefficient for H^+ when the equation below is balanced?

$$\_\_Pb(s) + \_\_NO_3^-(aq) + \_\_H^+(aq) \rightarrow \_\_Pb^{2+}(aq) + \_\_NO(g) + \_\_H_2O(l)$$

A. 2

B. 4

C. 6

D. 8

32. Which combination of signs for $E^\ominus$ and $\Delta G^\ominus$ correspond to a spontaneous electrochemical reaction?

	$E^\ominus$	$\Delta G^\ominus$
A.	+	+
B.	+	–
C.	–	–
D.	–	+

33. Which of the following factors affect the amount of product formed during electrolysis?

I. The current used

II. The duration of electrolysis

III. The charge on the ion

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

34. Which statement about neighbouring members of all homologous series is correct?

A. They have the same empirical formula.

B. They differ by a CH_2 group.

C. They possess different functional groups.

D. They differ in their degree of unsaturation.

35. Which compound can exist as optical isomers?

A. H_2NCH_2COOH

B. CH_2ClCH_2Cl

C. CH_3CHBrI

D. $HCOOCH_3$

36. Which product is formed by the reaction between CH_2CH_2 and HBr?

A. CH_3CH_2Br

B. CH_2CHBr

C. BrCHCHBr

D. CH_3CHBr_2

37. How many lines are present in the ^1H NMR spectrum of $C(CH_3)_4$?

A. 1

B. 3

C. 4

D. 12

38. In which of the following ways does benzene, C_6H_6, react?

I. Combustion
II. Hydrogenation
III. Substitution

A. I only

B. I and II only

C. I and III only

D. I, II and III

39. Which reaction(s) involve(s) the formation of a positive ion?

I. $CH_3CH_2CH_2Br \square OH^-$

II. $(CH_3)_3CBr \square OH^-$

A. I only

B. II only

C. Both I and II

D. Neither I nor II

40. What is the major product formed when a mixture of CH_3CH_2OH and concentrated H_2SO_4 is heated strongly?

A. CH_3CH_3

B. $CH_3CH_2SO_4$

C. CH_3COOH

D. CH_2CH_2